

Any of the embodiments described above may further include a source for providing radiation, wherein the array of mask apertures is positioned to receive the radiation and radiate a portion of the radiation to an object through each aperture.

Other aspects, advantages, and modifications are within the scope of the following
5 claims.

What is claimed is:

10/20/2019 10:20:00 AM

1. A multiple-source array for illuminating an object, the multiple source array comprising:

a source of electromagnetic radiation having a wavelength λ in vacuum; and

a reflective mask positioned to receive the electromagnetic radiation, the reflective mask comprising an array of spatially separated apertures, wherein each aperture comprises a dielectric material defining a waveguide having transverse dimensions sufficient to support one or more guided propagating modes of the electromagnetic radiation extending through the mask, each aperture configured to radiate a portion of the electromagnetic radiation to the object.

2. The multiple source array of claim 1, wherein the reflective mask further comprises a reflective dielectric stack surrounding the array of apertures.

3. The multiple source array of claim 1, wherein the mask further comprises an end mask portion positioned adjacent the object, and wherein each aperture further comprises a secondary aperture formed in the end mask portion and aligned with the corresponding waveguide, wherein each secondary aperture has a transverse dimension smaller than the transverse dimensions of the corresponding waveguide.

4. The multiple source array of claim 3, wherein the transverse dimension of each secondary aperture is smaller than the vacuum wavelength of the electromagnetic radiation provided by the source.

5. The multiple source array of claim 3, wherein the mask further comprises a reflective dielectric stack surrounding each of the waveguides.

6. The multiple source array of claim 5, wherein the end mask portion comprises a metal layer.

7. The multiple source array of claim 3, wherein each waveguide defines an optical cavity between opposite sides of the mask, and wherein the length of each waveguide is selected to cause the optical cavity to be resonant with the electromagnetic radiation.

5

8. The multiple source array of claim 2, wherein the reflective mask further comprises an antireflection coating positioned adjacent the object.

9. The multiple source array of claim 1, wherein at least some of the apertures are substantially cylindrical and the cylindrical apertures have a diameter on the order of $\lambda/2n_3$, where n_3 is the refractive index of the dielectric material in each corresponding aperture.

10

10. The multiple source array of claim 1, wherein at least one of the transverse dimensions of each aperture is on the order of $\lambda/2n_3$, where n_3 is the refractive index of the dielectric material in each corresponding aperture.

15

11. The multiple source array of claim 10, wherein another of the transverse dimensions of at least one of the apertures is smaller than $\lambda/2n_3$.

10420

12. The multiple source array of claim 1, wherein at least some of the apertures in the reflecting mask define a periodic array.

20

13. The multiple source array of claim 12, wherein the periodic array comprises a multi-aperture basis.

25

14. The multiple source array of claim 1, wherein the apertures comprise a first set of apertures having properties sufficient to support a first set of one or more guided propagating modes of the electromagnetic radiation extending through the mask and a second set of apertures having properties sufficient to support a second set of one or more guided propagating modes of the electromagnetic radiation extending through the mask,

30

wherein the first set of one or more guided propagating modes differs from the second set of one or more guided propagating modes.

15 15. The multiple source array of claim 14, wherein the first set of apertures define a first periodic array of apertures and the second set of apertures define a second period array of apertures.

16. The multiple source array of claim 1, wherein the dielectric material in at least one of the apertures is silicon.

10

17. The multiple source array of claim 1, wherein the wavelength λ is an optical wavelength.

18. The multiple source array of claim 1, wherein the source directs the electromagnetic radiation to contact the reflective mask at an angle with respect to a normal axis for the mask.

19. The multiple source array of claim 1, wherein the source directs the electromagnetic radiation to contact the reflective mask as a standing wave pattern.

20. The multiple source array of claim 2, wherein the reflective dielectric stack comprises alternating layers of different dielectric materials.

21. The multiple source array of claim 20, wherein the refractive indices of the dielectric materials in the alternating layers are smaller than the refractive index of the dielectric material in each aperture.

22. The multiple source array of claim 2, wherein the reflective mask further comprises a reflective/absorbing layer positioned to attenuate evanescent components of the guided propagating modes extending away from the apertures.

23. The multiple source array of claim 22, wherein the reflective/absorbing layer is a metal layer.

24. The multiple source array of claim 22, wherein the reflective/absorbing layer has thickness greater than the skin depth of the electromagnetic radiation for the reflective/absorbing layer material.

25. The multiple source array of claim 22, wherein the reflective/absorbing layer is positioned on one side of the dielectric stack.

26. The multiple source array of claim 22, wherein reflective mask further comprises a dielectric screening layer, and wherein the reflective/absorbing layer is positioned between the dielectric screening layer and the dielectric stack.

27. The multiple source array of claim 22, wherein the reflective/absorbing layer is formed by a series of pads in a common plane, wherein adjacent pads are spaced from one another by an amount sufficient to suppress plasmon oscillations in the reflective/absorbing layer.

28. The multiple source array of claim 1, further comprising an optical substrate attached to the reflective mask, wherein the optical substrate is substantially transparent to the electromagnetic radiation.

29. The multiple source array of claim 28, wherein the optical substrate provides mechanical stability to the reflective mask.

30. The multiple source array of claim 28, wherein the optical substrate comprises a curved surface to provide light gathering or focusing.

31. The multiple source array of claim 1, further comprising a uniform dielectric layer formed over the reflective mask, wherein the dielectric material in the apertures and the dielectric layer formed over the mask comprise a common dielectric material.

5 32. The multiple source array of claim 31, further comprising an anti-reflection coating formed over the uniform dielectric layer.

33. A multiple-source array for illuminating an object with electromagnetic radiation having a wavelength λ in vacuum, the multiple-source array comprising:

10 a reflective mask comprising an array of spatially separated apertures, wherein each aperture comprises a dielectric material defining a waveguide having transverse dimensions sufficient to support one or more guided propagating modes of the electromagnetic radiation extending through the mask, each aperture configured to radiate a portion of the electromagnetic radiation to the object.

15 34. A method for illuminating an object with electromagnetic radiation having a wavelength λ in vacuum, the method comprising:

 providing a mask comprising an array of waveguides; and
 coupling a portion of the electromagnetic radiation through each waveguide to
20 illuminate different spatial regions of the object.